UNIVERSITY OF SASKATCHEWAN
DEPARTMENT OF ELECTRICAL ENGINEERING
EE 395.3 – Electrical Engineering Design
Final Examination

April 19, 2002

Instructor: R. E. Gander and A. Kostiuk

Time: 3 Hours

Notes: **Open Book Exam**
1 textbook, course notes, and course assignments allowed.
ANSWER ALL QUESTIONS (1 – 5)

---

[20] 1. After reviewing the design of your digital logic probe, your customer complained about two characteristics: a) the brightness of the LEDs changed with the power supply voltage of the circuit under test and b) the continuous tone can be annoying. Provide suggested changes to your circuit that would keep the LED light output levels constant independent of the power supply voltage and that would have the tones generated for a fixed short period of time whenever there is a change in logic level.

[15] 2. An abbreviated statement of work for a residential furnace thermostat is given below. Draft a Requirements Specifications for the thermostat based on the statement of work. Your draft should include the section headings for the functional characteristics with as much content as possible. There will be some parameters and perhaps functions that are not completely clear from the statement of work. Include a set of questions that you would address to the customer that would allow you to complete the requirements specification. You do not need to include the acceptance tests in this draft.

Residential Furnace Thermostat

An electronic thermostat is required to control residential (and small commercial) furnaces. The device is to have only a single set point adjustable within the normal household range of temperatures. The adjustment may be either continuously variable or in small steps. There is to be set hysteresis around the set point. There is to be a display of the set point and of the room temperature. Both are to be in degrees Celsius. It is desirable to have these easily changeable during manufacture to degrees Fahrenheit. The thermostat is to connect to the two wires from a standard, 24-volt, furnace controller. NO additional wiring is acceptable. The device should be similar in size to currently available mechanical-type thermostats. The thermostat must not require maintenance more frequently than on a yearly basis. Its cost should be competitive with mechanical thermostats and less than programmable, digital thermostats.
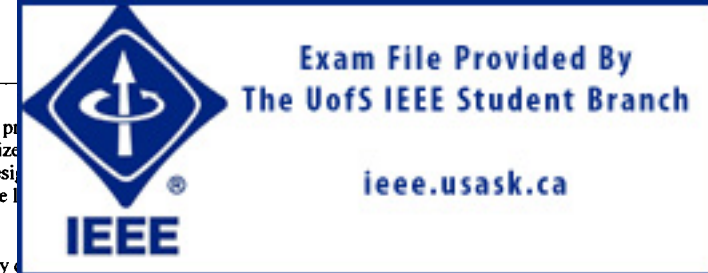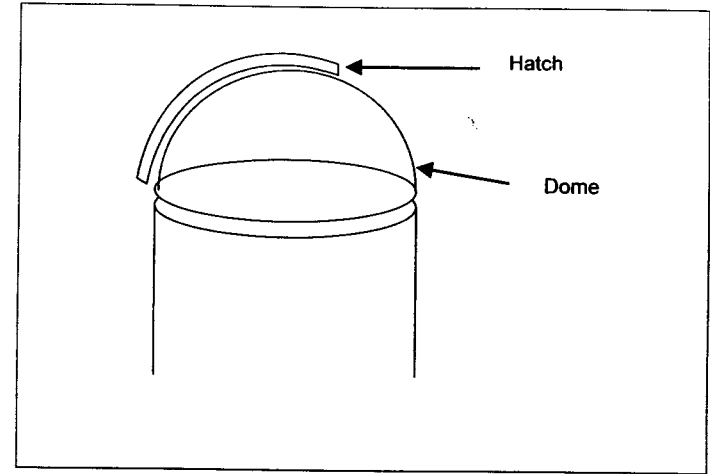

A laboratory pr[...]
the desired size[...]
within the desi[...]
15, 2002. The [...]
2002.

[15] 3. An astronomy [...]
control access across the Internet. One of the design challenges is to automate the "hatch" of the observatory dome:

The hatch is a door that opens sideways. The dome is a freely rotating hemisphere that rotates on the top of the observatory walls using wheels in a track. Note that the opening in the dome when the hatch is open extends from the horizon to past the zenith (point straight up in the sky), i.e., more than 90 degrees.

The hatch will require a motor to be added to it to open and close the hatch as well as a control system that can be remotely controlled to activate the motor. The motor does not need to be very powerful as the hatch can be moved easily on its sliders. The hatch will typically be opened once at the start of an evening observing session and then closed at the end of the session.

Because the dome can rotate in either direction for an arbitrary number of revolutions and the hatch and the hatch motor are attached to the dome, conventional use of wiring to power and control the motor for the hatch is not possible (the wiring would get twisted and broken). The observatory is unattended for long periods of time so all solutions need to run without human intervention.

a) Provide three options for powering the motor. Discuss the advantages and disadvantages of each option.

b) Provide two options for controlling the motor. Discuss the advantage and disadvantage of each option.

c) One issue someone raises that the telescope inside the observatory can get damaged if the hatch is opened when there is inclement weather outside. Provide two approaches to add automatic weather detection to the hatch controller so that the hatch will not be opened by remote control if the weather is bad. Discuss the advantages and disadvantages of each approach.

[20] 4. The "rules" for the operation of an Elevator Controller for a single elevator to provide fair yet efficient service can be summarized as:

a) Once moving in one direction (i.e., either up or down), do not change direction until all requests above you (when going up) or below you (when going down) are serviced.

b) If multiple requests for going down are received from floors above you, proceed to the topmost request first.

c) If multiple requests for going up are received from floors below you, proceed to the bottommost request first.

If you were to design a controller to simultaneously control two adjacent elevators, the rules would be different, as more options exist. List the rules you would use in the design of a two-elevator controller to provide fair and efficient service.

[30] 5. Your company is to receive a shipment of 20 function generators (HP8111A with Opt W30 and HP5062-3972). It is necessary to determine that each of the units is functional before being put into routine use in a production facility. On the basis of the abbreviated specifications given on the attached page, design a set of acceptance tests to be performed by one of the technicians in your department. Your department is well equipped with laboratory test equipment, connectors, cables, and components. The characteristics in the General category of the specifications need not be tested. The function generators will be used in normal and voltage controlled oscillator (VCO) modes. Your acceptance tests should also indicate what information is to be reported back to you.

The End

FUNCTION GENERATORS & WAVEFORM SYNTHESIZERS

1 Hz–20 MHz Pulse/Function Generator

HP 8111A

437

- Sine, triangle, square, haverfunctions
- 20 MHz, 32 Vpp for all waveforms
- Variable duty cycle or pulse width

- Trigger, gate, VCO and optional burst
- Digital display for all parameters
- Error recognition

Picture shows 8111A with Option 001, Counted Burst.

The HP 8111A combines pulse generator and function generator capabilities in a single, compact unit. Triggered operation for all waveforms, and the ability to define rectangular waveforms in terms of pulse width or duty cycle, are examples of the HP 8111A's versatility.

Saves Space and Equipment

Small size and manifold capability make the HP 8111A an ideal source for service and bench. Digital display, error detector and good repeatability assure high operating confidence. This reduces the need for output monitoring and consequently saves equipment.

Flexible

Operating modes include VCO which permits frequency-shift keying and dc-to-frequency conversion as well as sweep and FM applications. Option 001's Burst mode simplifies tone burst generation and digital preconditioning by generating a precise number of waveform cycles. An "extra cycle" feature activated after a burst allows critical events to be examined.

Pulse mode's variable width down to 25 ns and clean 10 ns transitions provide useful digital test capability. High analog flexibility is assured because all waveforms can be generated in trigger, gate and burst modes. Adjustable duty cycle up to 999 kHz means that CRT sawtooth waveforms and rectangular signals for dc motor control can be simulated.

Specifications (50-ohm load resistance)

Waveforms

sine, triangle, ramp, square, pulse, haverfunctions.

Timing

Frequency
Range: 1.00 Hz to 20.0 MHz (3-digit resolution).
Accuracy (50% duty cycle): 5% (±10% below 10 Hz).
Jitter: <0.1% + 50 ps.
Stability: ±0.2% (1 hour), ±0.5% (24 hours).
Duty cycle (sine, triangle, square, haverfunctions):

	Calibrated	Variable (below 1 MHz)
Range	50% normal	10% to 90%
Resolution	2 digits	2 digits
Accuracy	±1 digit	±6 digits
		(±3 in range 20 to 80%)

Pulse width
Range: 25.0 ns to 100 ms (3-digit resolution).
Accuracy: ±5% ±2 ns.

Output Characteristics
(voltages double into high impedance)
Amplitude
Range: 1.60 mVpp to 16.00 Vpp (3½ digit resolution).
Accuracy: ±5% (at 1 kHz for sine and triangle).
Flatness (sine, triangle): ±3% (+10%, −15% above 1 MHz).
Offset
Range: 0.00 mV to ±8.00 V (3-digit resolution).
Accuracy: ±5% setting ±2% amplitude ±20 mV
(ampl ≥ 160 mVpp).
±5% setting ±2% amplitude ±1 mV
(ampl < 160 mVpp).
Distortion: THD (1 Hz–1 MHz) < 3% (−30 dB); harmonics (1 MHz–20 MHz) < −26 d/Bc. Distortion may increase by 3 dB below 10°C and above 45°C.
Linearity (triangle): < ±3% (< ±1% below 1 MHz)
Pulse and squarewave performance
Transitions: < 10 ns.
Perturbations: < ±5% (< ±10% below 0.16 Vpp).
Output impedance: ±50 ohm ±5%.
Modes
normal, trigger*, gate*, VCO and (Option 001) burst*.
*Adjustable start-phase for haversine, havertriangle
VCO range: 2 decades, ext. signal 0.1 V to 10 V (dc to 1 kHz).
Burst length: 1 to 1999 periods for all waveforms.
General
Repeatability: factor 2.5 better than accuracy.
Environmental
Storage temperature: −40°C to +75°C.
Operating temperature: 0°C to 55°C.
Humidity: 95% RH, 0°C to 40°C.
Power: 100/120/220/240 V rms, +5% − 10%, 48 to 440 Hz; 70 VA max.
Weight: net, 4.6 kg (10 lb). Shipping, 6.6 kg (15 lb).
Size: 89 H x 212.3 W x 345 mm D (3.5" x 8.36" x 13.6").
Ordering Information
HP 8111A Pulse/Function Generator
Opt 001 Burst
Opt 910 Extra Operating and Service Manual
Opt W30 Extended Repair Service
HP 5062-4001: Bail Handle Kit
HP 5062-3972 Rack Mount Kit (single HP 8111A)
HP 5062-3974 Rack Mount Kit (two instruments)
HP 5062-3994 Lock Link Kit (for use with HP 5062-3974)